GIS Basics

- Key Concepts
  - Layers
    - "The visual representation of a geographic dataset in any digital map environment." Each distinct layer necessarily contains spatial data (i.e. information describing its position and extent, for the purposes of display), but can also contain non-spatial data (e.g. names, numbers, etc)
      - Think of transparencies on an overhead projector, but each is associated with its own spreadsheet, which is called an "attribute table"
      - Roads, rivers, lakes, cities, political boundaries, and natural topography will often occupy different layers
    - Layers take one of three forms:
      - Points – data appear as zero-dimensional points, with simple coordinates (Cartesian x-y or latitude-longitude)
        - Often used for cities and buildings
      - Lines – data appear as one-dimensional line segments
        - Often used for rivers, roads, railroads, trade routes
      - Polygons – data appear as two-dimensional closed shapes
        - Often used for administrative units, ecological regions
    - Order matters -- layers on top of the stack (those "nearest to the viewer") will be superimposed over layers underneath them
  - Symbology
    - Rules and conventions for the appearance of GIS data on the map; should generally be spelled out in a legend. Important for making the data clear and – if applicable – argumentative
    - Topics of concern include choice of symbols, colors, sizes, and opacity
      - For example, will cities be represented by dots or crosses? Will cities' populations be represented by the size of the dot, or the color, or something else? Will railroads be represented by generic lines or by "tracks"?
    - Different layers should have different symbology…
      - Layers should be immediately distinguishable from one another
      - Layers shouldn't obscure one another – you may want to adjust opacity, etc. so that they're all visible
    - …but symbology can (and often should) vary within layers too
      - For example, in a layer that simply depicts the location of different administrative units, no unit should be adjacent to a unit with the same color. If you want to highlight the difference of some measure across administrative units – e.g., the number of K-12 schools in counties in Kansas – a "heat map" color scheme might be chosen

- Potential Uses of GIS
    - Static map production – for conference presentations, print publications
    - Dynamic online maps – for teaching
    - Analysis – for research
        - The workflow will be largely the same regardless of ultimate purpose – and as a bonus, a GIS project originally intended for a PowerPoint can be easily repurposed for statistical analysis, or vice versa

- Potential Data Sources
    - Old – existing, possibly physical maps or other geographical representations imported into GIS as images (.jpg, .png, etc)
        - Usually not worth the trouble – end result is often aesthetically unappealing and analytically unhelpful due to the distortions involved in projecting the existing map onto the rigorous GIS coordinate system
    - New – self-produced GIS datasets / layers
        - Points are easiest to produce, but lines and polygons can be made also
        - Can be created by modifying pre-existing GIS datasets / layers
    - Borrowed – pre-existing GIS datasets / layers
        - Produced by individuals and by academic and governmental institutions – usually standardized and thus easily integrated into your own work
        - Saves the work of recreating basic data (e.g. national boundaries) – and usually easily modified
        - Sometimes sold but often free and downloadable online

- Software
    - Comprehensive GIS Applications
        - ArcGIS – the dominant GIS platform, produced by ESRI
            Pros: Powerful, comprehensive, well-documented
            Cons: Potentially costly, Windows-only

        - QGIS – the major alternative, free and open-source software
            Pros: No cost, versatile, works on all major operating systems; integrates well with other FOSS GIS packages (e.g. GRASS, a shell-based GIS system)
            Cons: Less user-friendly, less polished (esp. when it comes to cartography), not quite so powerful as ArcGIS

- Lightweight GIS Applications / Viewers
  - Google Earth / Google Earth Pro
    - Pros: User-friendly, visually appealing, includes considerable unstructured geographical data, free of cost (Pro requires registration)
    - Cons: Extremely limited functionality as a general-purpose GIS application – best suited for viewing data, or producing specific types of data

- Online GIS Viewers / Repositories
  - WorldMap – open-source software managed by Harvard University
    - Pros: User-friendly, free of cost, robust permissioning; can upload own layers or download others'
    - Cons: Symbology can be difficult to refine in-app

  - ArcGIS Online – online version of ArcGIS, produced by ESRI
    - Pros: User-friendly
    - Cons: Limited functionality without paid subscription; not as powerful as WorldMap

- Advanced Statistical Applications (will not be covered today)
  - GeoDa – open-source software managed by Arizona State University
    - Spatial statistical software with which you can run significance tests and spatial regressions on shapefiles
    - Free of cost, powerful, but requires some proficiency in statistics
  - R
    - Preeminent statistical package; can also be used for GIS purposes

Workflow for Creating a Map in ArcGIS

1) **Open ArcMap. At the "Getting Started" screen, select "Blank Map" from "My Templates."**
   - **a.** If you have saved map files on the computer, they can also be accessed from here.
   - **b.** ArcMap also provides a few templates from which you can choose.

2) **Place a "reference" layer (or layers) on your map. There are two ways to do this:**
   - **a.** Add a "Basemap" provided by ESRI.
     - Pros: Convenient, risk-free, aesthetically appealing; includes geodetic (i.e. projection) information
     - Cons: No real functionality (it's more or less just a background image), can't be modified (e.g. labels and other elements can't be removed), often presentist
   - **b.** Add one or more shapefiles provided by a third-party source that depict landmasses, bodies of water, etc.
     - Pros: Flexible, functional
     - Cons: May require aesthetic tweaking; issues with projection possible

   For this exercise, we will simply use one of ESRI's basemaps. Choose the "Imagery" basemap from the menu at File / Add Data / Add Basemap (or the pulldown menu next to the "Add Data" button).

3) **Add "off-the-shelf", pre-made layers to your map.**
   - **a.** Find the layer(s) you want – e.g. in an online repository – and download them. They typically come in .zip packages that usually contain
     i. A shapefile (.shp) – the most important element, containing the feature's geometry
     ii. A shape index format file (.shx) – contains a positional index for the feature's geometry
     iii. An attribute or database file (.dbf) – closely akin to an Excel spreadsheet; contains rows and columns with information associated with each shape
     iv. A project format file (.prj) – describes the coordinate system and projection information; sometimes not included
   - **b.** Extract the downloaded .zip archive to a local file folder that is linked to your ArcGIS installation's data catalog.
     i. If the folder containing the shapefile has NOT been added to your ArcGIS catalog, you can add it by clicking the icon on the upper right of the Open File window that has a plus symbol superimposed over a folder.
   - **c.** Click File / Add Data / Add Data, or use the "Add Data" button, and add the shapefile (.shp); ArcMap will automatically import the associated files (i.e. the .shx, .prj, etc. files with the same name).

i. If there is a mismatch between the projections used by new data and data already on the map, ArcMap will notify you and attempt to make the requisite transformations.

d. The layer should now appear on the map.

I've already downloaded a number of layers from www.kansasgis.org, which you can find in the folder you downloaded from Hawk Drive. Add that folder to your ArcGIS data catalog and then add the following shapefiles following the directions above; you're welcome to add more from the folder if you'd like to do so. You may get warnings about transformations with some of the shapefiles; ignore those for the time being.

Polygons

Tiger2010_Census_County.shp
WindFarms_Jan2012.shp
TMDL_LAKES.shp
rare_species.shp
prairie_chicken_range.shp
ecoregions.shp

Vectors

TMDL_RIVERS.shp
Tiger2010_Railroads.shp

Points

hospitals.shp
parks.shp
primary_secondary_schools.shp

4) <u>Refine the symbology of your layer(s).</u>

a. Either fast double-click a layer, or right click it and select "Properties", to get a detailed look at its settings. Some highlights…

i. The "General" tab lets you rename the layer (you can also do this by slow double-clicking it in the Table of Contents), write out a description of it, credit it to someone, and set its visibility (i.e. make it visible or invisible at particular zoom scales.)

ii. The "Source" tab gives you detailed information about the data source – its filename, geometry type, and its projection (i.e. Geographic Coordinate System).

iii. The "Display" tab lets you set the layer's transparency – if the layer is a polygon and you want to permit underlying physical features (from the basemap or some other layer) to be visible, set the transparency around 50-60%.

iv. The "Symbology" tab is especially important

1. For polygons – it's here that you can give different units different colors. The default option is Features / Single symbol, with a set color. Usually, you'll want to instead opt for one of the following options:

a. Categories / Unique values – good for arbitrarily assigning colors that will differ for each unit
    i. Select a value field (i.e. column from the layer's attribute table) that will determine the color.
        1. If you select the layer's index column, each unit will have its own color, as each unit will be guaranteed a unique index number.
    ii. Select a color ramp based on your aesthetic preference. The more varied the colors, the less likely that adjoining units will look similar.
    iii. Click the button "Add All Values" and then "Apply." Your layer should have its different elements color-coded.
b. Quantities / Graduated colors – good for producing "heatmaps"
    i. Select a value field that will determine the color – if you want it to be a "heatmap" based on a count of points joined to a polygon, choose "Count_" as the value.
    ii. In the box at the upper right titled "Classification", select the number of Classes from the radio menu – this will decide how many different colors will actually appear on the map.
    iii. Choose a color ramp – cool to warm is usually best.
    iv. The table will show the color and the corresponding number. Press "Apply" to see the result on the map.
c. Others
    i. You can also assign different dot sizes or miniature charts to the polygons using other choices in the menus at left; be aware, however, that these will obscure the landscape more than the areal representations discussed above, and may prove confusing to the viewer.

2. For points – you'll generally just use the default Features / Single symbol option here, but you may want to customize that symbol. Click the button with the symbol on it to access the "Symbol Selector" screen, where you can choose a different shape, color, and size for the point.
3. For vectors – you'll be able to change the thickness and color of the vectors here.
4. If you want to change any individual symbols (be they the single symbol for a layer of points, or a color for one part of a layer of polygons), click the icon which appears under the layer in the Table of Contents.

v. The "Labels" tab lets you specify whether text labels will appear on the map, and how they will be labeled; you can specify the field (from the attribute table)

that will provide the label, and the font, color, size, etc of the label's lettering. You can also tweak its placement relative to the layer.

1. Be warned that labels can go wrong very easily: it's easy to inadvertently make them disappear, and hard to make them appear in precisely the place you want them to.

For this exercise, make the following modifications to the layers you've uploaded:

hospitals.shp

Rename to "Hospitals and Medical Facilities"; change the symbol to a size 10 "Hospital 2" icon.

parks.shp

Rename to "Public Parks"; change symbol to a size 3 green dot.

primary_secondary_schools.shp

Rename to "Schools (K-12)"

Tiger2010_Railroads.shp

Rename to "Railroads"; change symbol to "Railroad, Multi-Track"

TMDL_Rivers.shp

Rename to "Rivers"; change symbol to "Rivers", decrease width to 0.5

ecoregions.shp

Change the symbology so that each region has its own color, and the layer's transparency is 50%

WindFarms_Jan2012.shp

Change the symbology so that the windfarms are noticeable when viewing the state of Kansas as a whole (they don't occupy much area)

TMDL_Lakes.shp

Rename to "Lakes and Reservoirs"; change their color to blue.

Tiger2010_Census_County.shp
Tiger2010_Census_CountySubdivision.shp

Rename these files as you see fit, then color code them so that each county and subdivision thereof has its own color. Label each county so that its name appears only when the scale is less than 1:6,000,000; label each county subdivision so that its name appears only when the scale is less than 1:750,000. Toggle them off when you're done.

prairie_chicken_range.shp

Rename this file to "Prairie Chicken Range" and change its symbology to represent a grassland; don't worry if it isn't easily visible for the moment.

Basemap

Toggle the basemap off. You should still recognize the state of Kansas. Feel free to try toggling other layers on and off.

5) <u>Take a look at the layers you've imported.</u>

a. There are two major ways to do this:

i. Press the "Identify" button on the Tool toolbar (the icon with the letter "i" superimposed on a blue circle), and then click on a point on the map. A window will open showing the attributes of all of the features near the point you clicked. You may need to choose from several features to inspect – they are listed in the top half of the "Identify" window.

ii. Right click a layer in the Table of Contents, and select the option "Open Attribute Table." You will see the .dbf file (originally an Excel file, if you added the XY point data yourself that way) with rows and columns. You can change the order in which data is displayed by right-clicking the column headers; you can also search all of the table's fields via the "Find and Replace" command in the Table Options menu, at the upper-left corner of the window.

Use the methods above to answer these questions:

What is the name of the two schools (an elementary and a junior-and-senior high school) closest to the northwest corner of Kansas? What county are they in? What township?

In what ecoregion is Lawrence located?

How many beds does the hospital in Ottawa County have?

6) <u>Add data you produced yourself to the map – Points</u>

a. Create an Excel spreadsheet (preferably in .xls format), with each row corresponding to a datapoint and each column corresponding to information about that datapoint.

i. At minimum, Excel spreadsheet should have the following columns:

1. An "ID" column, with an index number (1, 2, 3…) associated with the point
2. A "name" column, which will identify the feature (and – if you choose – be used as a label)
3. An "x_coord" column and a "y_coord" column, which will contain the decimal (***not*** DMS, i.e. degrees-minutes-seconds) coordinates used by ArcMap to place the point.
    a. If you're unsure of the coordinates of your point there are two easy ways to determine them:
        i. For a city, look up the location in Wikipedia; the latitude and longitude using the (common) WGS84 projection will usually be listed as DMS values under the place's

locator map. Click the hyperlink to see more detailed information (including the decimal conversion)

ii. Open Google Earth and mouse over the location you hope to enter as a point (ou can use the in-app search engine if you'd like); write down the DMS coordinates and then use an online calculator to convert them to decimals.

b. Be sure you've included the right positive/negative signs on your coordinates, and that you have the right values in the right places.

i. Usually, DMS coordinates are given as (latitude, longitude), whereas Cartesian x-y coordinates are given as (x, y). The decimal latitude should be the y coordinate, and the decimal longitude the x coordinate.

ii. In ArcMap, go to File / Add Data / Add XY Data.

1. Specify the Excel spreadsheet (and sheet within the spreadsheet) from which you'll be extracting points, and assign the "X Field" to the "x_coord" column, and likewise with Y. By default, ArcGIS will assume that your coordinate values are meters, not degrees (i.e. that you're using the WGS 1984 Web Mercator Auxiliary Sphere coordinate system, which is a projected coordinate system; the latitude and longitude measurements used in Google Earth, and Wikipedia, and most other places you might look, use plain-old WGS 1984, which is a geographic coordinate system). To fix this, click the "Edit" button near the bottom of the window; then, scroll up and select Geographic Coordinate Systems / World / WGS 1984, and click OK. Click OK again. You'll likely get a warning that your table does not have an "Object-ID" field. (This occurs even if you gave your index column that name.) Ignore it and click "OK". Your XY data will now appear on the map. If you want to save them as a shapefile, you can do so by exporting them.

Create a layer of your own, with three data points – they could represent cities, or locations in Lawrence, or whatever you'd like. Be sure to give them indices, names, and decimal coordinates; you can include any other data you'd like, but be sure that the top row for each column has an explanatory name.

7) **Add data you produced yourself to the map – Vectors and Polygons**

i. These are difficult to produce with precision. But, there are two ways to produce them freehand.

1. RECOMMENDED: In Google Earth

a. Open Google Earth (Pro or not – doesn't matter)

b. Zoom in to the place where you want to draw your vector or polygon.
c. Click the “Add Path” or “Add Polygon” button, on the bar above the map view.
d. Draw your path or polygon.
    i. Polygon – Click the mouse at the point at which you’d like to start, and then either hold down the mouse button while you outline the shape of the polygon, or release it and click it again over the vertices of the polygon (the program will automatically draw edges between the new vertex and the last one, and fill in enclosed space; the edge between your last click and the point of origin will be automatically drawn).
    ii. Path – Same as polygon, but without the closing edge or the fill-in.
e. Fill in whatever information you’d like concerning the path or polygon in the window that’s automatically generated, and define its appearance.
    i. Description – give it a title and a short description (you can include links or images)
    ii. Style, Color – specify the line (and, with polygons, area) color, width/fill, and opacity.
    iii. View – (not as important)
    iv. Altitude – by default, the path or polygon is clamped to the ground. Usually best not to change this.
    v. Measurements – gives you statistics about the path/polygon you’ve drawn (area, perimeter, length).
f. Right-click your newly created path(s) and/or polygon(s) in the “My Places” menu on the left sidebar and select “Save Place As…”. Save it to your GIS workfolder as a .kml file, ***not*** as a .kmz file.
g. Open your map in ArcMap and open the ArcToolbox; go to Conversion Tools / From KML / KML to Layer. Select your newly-created .kml file and click “OK.”
h. Your .kml file should appear on the map as a layer (.lyr). If you want to export it as a shapefile (.shp), right click on the data type (i.e. “Polygons” or “Polylines”) in the Table of Contents, go to “Data… / Export Data”, give the new shapefile a name, and then click “OK”.

2. NOT RECOMMENDED: In ArcMap

a. Open the Editor Toolbar, press the "Editor" button, and click "Start Editing." When prompted, choose a layer or workspace in which the editing will occur. Ignore any warnings you see.
b. Click the rightmost button on the menu – "Create Features."
c. In the "Create Features" window, choose a layer which will serve as a template for the new features you create.
d. Use the indicated tools to draw lines, shapes, etc.

Add one polygon and one vector to the map. Possible polygons include: a park you enjoy visiting (the parks.shp file included is points, not polygons), or the neighborhood in which you live. Possible vectors include your favorite running routes, or your commute to campus.

8) <u>Select subsets of data points from existing layers, by location or attribute(s).</u>

a. Select by location, across multiple layers
   i. Press the "Select Features" button on the Tool toolbar (the icon with a mouse pointer over a miniature map), or from the "Selection" menu at the top of the screen, and then draw a shape on the map (the default option is a rectangle); all of the features within the boundaries of the shape you've drawn will be "selected" and appear light blue on the map.

b. Select by attribute, within a given layer
   i. Open the "Selection" menu at the top of the screen and choose the "Select by Attribute" option. A window will appear wherein you can specify the layer from which you want to view a subset, and Boolean operations based on columns from the layer's attribute table.
      1. When possible, avoid typing here. Instead, double-click the list of column names, use the buttons provided to insert operators, and click "Get Unique Values" for a list of all the values that appear in the given column. Doing so decreases the probability of syntax errors. The criteria for selection will appear at the bottom of the window. Click "Verify" to ensure you don't have any typos.

c. Once you've selected features from a given layer by attribute, right-click on the layer in the Table of Contents, and navigate through the context menu to Selection / Create Layer from Selected Features.
   i. The selection now appears on the map as its own layer. You can save it to its own shapefile.

Create two new shapefiles: one consisting of all of the K-12 schools in/near Lawrence, and another consisting of all of the K-12 schools in the state which are <u>not</u> accredited.

9) <u>Create a new layer from the union or intersection of one or more existing ones</u>

a. Go to the "Geoprocessing" menu at the top of the screen and select an operation.
   i. "Intersect" lets you find the intersection (i.e. overlap) of the data layers you input and outputs it as a new layer.

1. Typically, you would be looking for the intersection of polygons (which will be polygons) or points and polygons (which will be points).

ii. "Union" works in the same way, and lets you produce the union (i.e. sum) of the data layers you input, outputting it as a new layer.

1. This comes in handy if you have multiple layers containing the same sort of information (e.g., you have one layer containing the schools of Douglas County and another the schools of Johnson County, but you don't need to make any distinction between them).

Create a new map layer that will show where the range of the prairie chicken overlaps with wind farms.

10) <u>Join layers together (a prerequisite for statistical analysis and areal representation, e.g. heat maps)</u>

- **a.** Choose the polygon layer which will be your unit of spatial analysis. This could be any polygon layer that overlaps with other layers; ideally, it will be comprehensive (i.e. cover the entirety of the area with which you're concerned) but also well-articulated (i.e. with lots of individual parts). Examples might be administrative units, ecoregions, etc.
- **b.** Right click that layer in the Table of Contents; in the context menu, select Joins and Relates / Joins.
- **c.** Ensure that the radio button at the top reads "Join data from another layer based on spatial location".
- **d.** Select the layer (typically consisting of points) which you want to join to the polygon layer, and which will determine how the polygon layer's parts will be coded.
- **e.** Usually, you'll want to select the option "Each polygon will be given a summary of the numeric attributes of points that fall inside it, and a count field showing how many points inside it." You'll want to check the box next to "Sum."
    i. This will tally how many points fall inside the given polygon, and the resulting joined layer will have a column titled "Count" containing the sum.
- **f.** Name the new polygon shapefile at the bottom, and click "OK." A new shapefile will be created.
    i. You can repeat this process an indefinite number of times; if you want to perform multivariate spatial regressions, you may do it dozens of times. Keep a careful record of each join – ArcMap's automatic naming conventions aren't very helpful, and without careful notes, or regular renaming of the columns in the polygon-plus layer's attribute table, you may wind up with little idea what your columns represent.

Use the procedures discussed above, and in the section on symbology, to create a heatmap showing where K-12 schools are located in Kansas; use either counties or townships as your unit of analysis.

11) **Prepare the map for export**

- **a.** Save the map as a .mxd file.
  - i. Note that the .mxd format does not itself contain all of the data represented on the map; (appropriately, perhaps) it's more like a map to the data, preserving the way they interconnect.
    1. If you move a .mxd file to another computer without the shapefiles, you won't be able to work with it.
    2. If you move a .mxd file to another computer with the shapefiles, you will be able to work with it, but will first have to "repair" the data connection by pointing a layer to its data source.
       a. If you've copied your entire GIS workspace file folder over to the new computer, and "repaired" one data connection, ArcMap will probably be able to restore all of the other data connections automatically.
- **b.** IF you want to export the map to an image file without any cartographic elements
  - i. Toggle layers and position the map view as you want the image file to appear.
  - ii. Go to File / Export Map.
  - iii. Select a destination folder for the file, choosing an image type from the radio button.
    1. In the "Options" at the bottom of the window, in the "General" tab, select a resolution and size for the image; if you want to modify the color (e.g. make it black-and-white), do so in the "Format" tab.
  - iv. Your image file is created, along with a (perhaps hard-to-read) credit caption in the lower right-hand corner.
- **c.** IF you want to export the map to an image file with cartographic elements
  - i. Toggle "Layout View" using the small button at the lower-left corner of the map view window; you will now see you map as if it were on a printed page. You can resize it by clicking on it and then expanding/shrinking it along its edges.
  - ii. Open the "Insert" menu at the top of the screen – you will be given several options for adding elements to your map. Conventionally, you should be sure to include a title, a legend (which should correspond to the layers on the map), a north-arrow, and a scale bar (the values of which will be automatically chosen by ArcMap). You will have options about the style of each of these, and can drag them into your preferred position on the page.
  - iii. Go to File / Export Map and proceed as explained above. An image file will be created that replicates the Layout View version of the map, including cartographic elements and any surrounding white space.
- **d.** IF you want to move one or more layers to Google Earth Pro (not possible in regular version)
  - i. Close ArcMap and open Google Earth Pro
  - ii. Go to File / Import
  - iii. Choose "ESRI Shape (*.shp)" as the file type.

iv. Open the shapefile. It will now be added to your "Temporary Places." Toggle it on and it will be visible on the globe.
v. If you want it to be permanently available, right click the layer and select "Save to My Places."

Try to export your map – with any arrangements of layers – both as an image and as a full-fledged map, complete with legend, scale bar, etc. Then take your heatmap layer and add it to Google Earth Pro.

GIS Resources Online

General Information

Stack Exchange – GIS (https://gis.stackexchange.com/)

Community of GIS enthusiasts & professionals; a great place to find answers to questions you may have. Many may already have been answered.

Reddit – GIS (https://www.reddit.com/r/gis)

Another active community of GIS enthusiasts and professionals.

GIS Wiki (http://wiki.gis.com/wiki/index.php/Main_Page)

A Wiki dedicated to GIS.

ESRI's GIS Dictionary (http://support.esri.com/en/knowledgebase/Gisdictionary/browse)

Contains entries on both general concepts and those specific to ArcGIS.

Applications and Tools

ArcGIS Desktop and ArcGIS Online (https://www.arcgis.com/home/)

The preeminent GIS application, and its recently-introduced online version. Available in select KU computer labs; single user licenses available for purchase at a significant discount. ESRI Help Resources (http://resources.arcgis.com/en/help/) is the hub for documentation on ESRI's various apps, including the last few versions of ArcGIS Desktop.

QGIS (http://www.qgis.org/en/site/)

The most popular alternative to ArcGIS, free and open-source. Not as polished, powerful, or user-friendly as ArcGIS. The Center for Geographic Analysis at Harvard has a useful tutorial online at http://maps.cga.harvard.edu/qgis/.

Google Earth / Google Earth Pro (https://www.google.com/earth/)

Free-of-cost software that's great for finding and viewing geographical data; useful too for producing lines and polygons that can be uploaded to ArcGIS. Tutorials available at https://www.google.com/earth/learn/.

WorldMap (http://worldmap.harvard.edu/)

An open-source and free-of-cost online mapping platform; a good place to find layers, and to build your own maps. Also great for teaching purposes.

GeoDa (https://geodacenter.asu.edu/)

Advanced spatial-statistical package, open-source and free-of-cost. Documentation and some videos available at the site.

FCC Coordinate Converter
(https://www.fcc.gov/encyclopedia/degrees-minutes-seconds-tofrom-decimal-degrees)

A handy tool for converting from DMS to decimal and vice versa; also has a calculator for converting between two common coordinate systems.

Data Sources

General

GIS Data Depot (http://data.geocomm.com/)

One of the larger spatial data repositories out there; can be a bit technical, but most of it is free if downloaded.

Natural Earth (http://www.naturalearthdata.com/)

Offers free shapefiles; many would be appropriate for replacing ESRI Basemaps.

Wikipedia (https://www.wikipedia.org/)

Most place-related articles include WGS84 DMS coordinates and a link to the topic's GeoHack page, where WG84 decimal coordinates (and also UTM coordinates) can be found.

Google Earth / Google Earth Pro (https://www.google.com/earth/)

Great for looking up the coordinates (in WGS84 DMS) of particular locations; in-app search engine also very useful.

Historical GIS Research Network (http://www.hgis.org.uk/resources.htm)

Contains descriptions of and links to numerous historical GIS projects, some of which provide data for download.

China

China Historical GIS (CHGIS) – Harvard University (http://www.fas.harvard.edu/~chgis/)
China Biographical Database (CBDB) – Harvard University
(http://isites.harvard.edu/icb/icb.do?keyword=k16229)
ChinaMap – Harvard University (http://worldmap.harvard.edu/chinamap/)
Digital Gazetteer of the Song Dynasty – Ruth Mostern and Elijah Meeks, UC Merced
(http://songgis.ucmerced.edu/)
Taiwan History and Culture in Time and Space – Academia Sinica (http://thcts.ascc.net/)
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